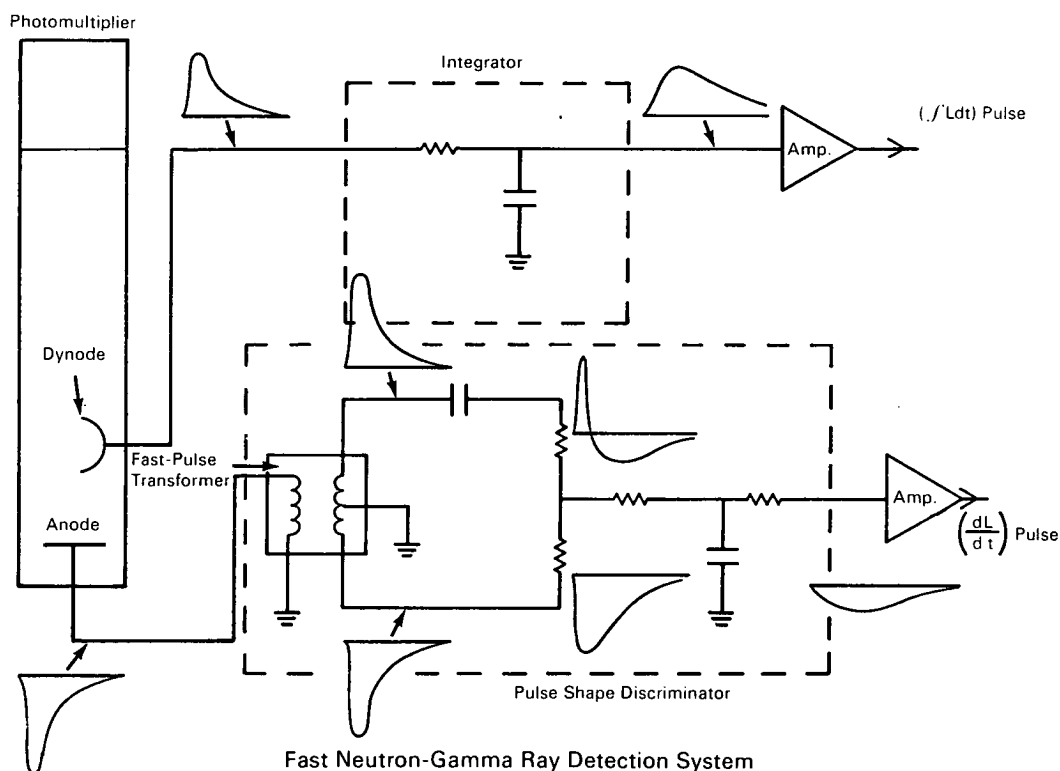


NASA TECH BRIEF



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Improved Pulse Shape Discriminator for Fast Neutron-Gamma Ray Detection System



A simple, inexpensive pulse shape discriminator has been designed for use in a nuclear particle detection system (including a photomultiplier and two-dimensional pulse height analyzer) to enable the system to simultaneously distinguish nuclear particle type and energy among many different nuclear particles (or radiation), e.g., γ , e , n , p , μ , and α . Previous systems can only discriminate between a maximum of two particles. The discriminator incorporates only passive, linear circuit elements, so that

it will operate reliably over a wide dynamic range. Other known pulse shape discriminators employ diodes and/or transistors. Since the circuit is composed of only passive, linear elements, it has an inherently high temperature stability. Additionally, the system is independent of photomultiplier high-voltage and gain changes since the discriminator operates from only one photomultiplier output. Other pulse shape discriminators generally require two or three separate multiplier outputs, which make

(continued overleaf)

the detection systems sensitive to any changes in photomultiplier characteristics and necessitate complicated readjustments.

As with other nuclear particle detection systems, the photomultiplier used with the new discriminator receives light pulses from an appropriate scintillator which absorbs energy from the nuclear particles and radiates (scintillates) this absorbed energy in a particular combination of modes. The time constants for the decay or relaxation of scintillation pulses depend upon the type and energy content of the exciting particle. Discrimination among the different types of particles is possible because the amplitude ratio of fast to slow components of the relaxations differ for each type of particle. The new system compares the slower secondary decay amplitudes to the total integrated amplitudes of all decays. The reason for using this method of comparison lies in the saturating, nonlinear characteristics of photomultipliers; that is, very fast, high-intensity decays cannot be faithfully followed by the photomultiplier because of space charge limitations.

Operation of the pulse shape discriminator is based on the partially destructive and partially constructive interference of a *pair* of electronic pulses derived from *one* scintillator-photomultiplier pulse. This one original pulse may be either from a photomultiplier dynode or anode (as illustrated). This *pair* of pulses is obtained from *one* pulse by means of a commercially available fast pulse transformer. Such a transformer will produce two conjugate, 180° out-of-phase, unipolar pulses from one input pulse, which are exactly in time coincidence. These two opposite-polarity pulses are then separately operated upon electronically. One pulse is RC-differentiated with a short time constant, thus producing a bipolar pulse. The other, an opposite-polarity pulse, is merely recombined by addition to suitably interfere and thereby cancel the first part of the RC-differentiated bipolar pulse. This cancellation produces an extremely shape-sensitive

output without the use of any nonlinear devices. The output is finally integrated before entering an amplifier. Since this amplified unipolar pulse is related to a differentiation, it is conveniently defined as the (dL/dt) pulse and is particularly dependent on *particle type*.

Simultaneously from a dynode, as illustrated, a pulse is taken, integrated for several decay periods, and then amplified. This amplified pulse is thus defined as the $\int Ldt$ pulse and is related to *particle energy*. The two pulses (dL/dt) and $\int Ldt$ are plotted against each other on a two-dimensional field (multi-parameter pulse-height analyzer) to show the particle separation and relative energy content.

Notes:

1. A disadvantage of this device is that it requires a two-dimensional pulse height analyzer, whereas most other pulse shape discriminator systems use only a one-dimensional analyzer.
2. It has been ascertained that some organic liquids and alkali halides may be used as scintillators for this system. It is believed that the system may also be used with solid state nuclear particle detectors.
3. No further documentation is available. Inquiries may be directed to:

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No patent action is contemplated by NASA.

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